

senting about 1/15 ampère. In two hours and a half the hydrogen introduced into the gas would be about 70 c.c., sufficient, if retained, to reduce the weight by about 4 per cent. The fact that there was no sensible reduction proves that the hydrogen was effectively removed by the copper oxide.

The nitrogen, obtained altogether in four ways from chemical compounds, is materially lighter than the above, the difference amounting to about 11 mg., or about 1/200 part of the whole. It is also to be observed that the agreement of individual results is less close in the case of chemical nitrogen than of atmospheric nitrogen.

I have made some experiments to try whether the densities were influenced by exposing the gas to the silent electric discharge. A Siemens tube, as used for generating ozone, was inserted in the path of the gas after desiccation with phosphoric anhydride. The following were the results :—

Nitrogen from Air by Hot Iron, Electrified.

January 1, 1894.....	2·31163	Mean, 2·31059
January 4, 1894.....	2·30956	

Nitrogen from N₂O by Hot Iron, Electrified.

January 2, 1894.....	2·30074	Mean, 2·30064
January 5, 1894.....	2·30054	

The somewhat anomalous result of January 1 is partly explained by the failure to obtain a subsequent weighing of the globe empty, and there is no indication that any effect was produced by the electrification.

One more observation I will bring forward in conclusion. Nitrogen prepared from oxygen and ammonia, and about one-half per cent. lighter than ordinary atmospheric nitrogen, was stored in the globe for eight months. The globe was then connected to the apparatus, and the pressure was re-adjusted in the usual manner to the standard conditions. On re-weighing no change was observed, so that the abnormally light nitrogen did not become dense by keeping.

II. "On Variations observed in the Spectra of Carbon Electrodes, and on the Influence of one Substance on the Spectrum of another." By W. N. HARTLEY, F.R.S., Royal College of Science, Dublin. Received January 13, 1894.

In a recently published paper by Eder and Valenta, on the "Line Spectrum of Elementary Carbon and the Ultra-violet Spark Spectrum of Wet and Dry Wood Charcoal" (Vienna, 'Akad. Wiss. Denkschriften,' vol. 60, 1893), there occurs this passage :—

"It is worthy of remark that Hartley and Adeney, among the carbon lines measured by them, included those with wave-lengths 3881·9, 3870·7, 3589·9, and 3584·8, which, according to the foregoing investigation, are described as the edges of cyanogen bands, and must be struck out of the list of lines in the spectrum of carbon. Liveing and Dewar, in their previous work on the graphite spark spectrum, had not recorded them, but these were first presented as new carbon lines by Hartley and Adeney."

At the time the observations of Mr. Adeney and myself were made there was no published description of the ultra-violet spectrum of carbon, but before our work received publication, that of Messrs. Liveing and Dewar appeared, and to this we referred ('Roy. Soc. Proc.', vol. 34, p. 429). The lines we described we still believe to be none other than carbon lines, because of the absence of satisfactory evidence to the contrary.

The carbon spectrum, as modified by moistening graphite electrodes and surrounding them with gases other than atmospheric air, was closely studied by me and the different spectra were mapped ('Phil. Trans.', Part I, 1884, p. 49). Not only was the carbon spectrum studied, but an endeavour was made to obtain the "cyanogen bands" from saturated solutions of cyanides. No success attended these experiments, even when on the one hand a stable cyanide such as the potassium salt was used, nor when the most easily decomposed salt, mercuric cyanide, was taken. On this ground there appeared to be no sufficient reason for attributing the lines 3881·9, 3870·7, 3589·9, and 3584·8 to cyanogen rather than to carbon. On the other hand, it was shown that some of the lines were much strengthened and the general appearance of the first group was altered when concentrated solutions of zinc and calcium chlorides surrounded the electrodes, but it was evident that the modification of the spectrum did not arise from the zinc, calcium, or chlorine, and, therefore, more probably the carbon lines were modified by the presence of the saline solutions.

The stronger the solutions the more pronounced were the modifications in the spectra. Eder and Valenta do not appear to have referred to these facts, and it is quite possible they may have overlooked pp. 58 and 59 of my paper, where they are recorded and discussed.

I have recently again examined a large number of photographs of spectra of saline solutions and several spectra of various flames taken in the years 1880-81. The graphite electrodes immersed in solutions show beautiful groups of lines which coincide with the edges of certain bands in spectra of the flame of burning cyanogen. These bands can be recognised in the groups III and IV on the spectra photographed by Kayser and Runge.

The origin of these coincident portions of spectra, namely, from the combustion of cyanogen and from carbon electrodes in saline solutions, taken in conjunction with the fact that they are not rendered by cyanides, makes it doubtful whether the cyanogen spectrum is not due to elementary carbon, as first advocated by Marshall Watts. There are other facts and circumstances which somewhat support this doubt. First, variations have been observed in the spectrum of carbon which cannot be easily accounted for. Secondly, the effect of one substance on the spectrum of another which I have recently observed not only strengthens weak lines but in certain cases brings a new series of lines into view. Thirdly, the spectra of mixed vapours have been shown to be different from the spectra of the substances by themselves (Liveing and Dewar, 'Roy. Soc. Proc.', vol. 34, p. 428); and, fourthly, the influence of the strong lines of an element on adjacent weaker lines of another substance is to strengthen the weaker lines in some cases, but almost to obliterate them in others.

In order the more readily to be able to refer to modifications in the carbon spectrum, I append lists of the lines which appear in different circumstances when condensed sparks are passed between graphite electrodes, so that at a glance it may be noted in what manner the spectra are modified. For comparison the edges of the cyanogen bands measured by Kayser and Runge, and the carbon lines as recorded by Eder and Valenta, are given. The difference between the wave-lengths quoted for the same lines is due chiefly to the different scales used, namely those of Ångström and of Rowland.

On examining these figures it will be observed that Hartley and Adeney's carbon line, 3881·9, may or may not coincide with the edge of the cyanogen band, 3883·6, of Kayser and Runge, but probably it does not. The carbon line, 3870·7 appears to coincide with 3871·7, the band of cyanogen, but there is no further agreement between the two spectra until we come to the three lines of carbon 3589·9, 3584·8, and 3583·5. The two lines 3881·9 and 3870·7 of carbon are obtained when dry electrodes are immersed in carbon dioxide, and under this condition the second line is greatly lengthened and both are much strengthened, whereas in atmospheric air, though the first is long, both are only feeble. With wet electrodes in air they are both long. With dry electrodes in oxygen 3881·9 is a long line, but 3870·7 is absent.

I conclude from these facts that, whatever may be the origin of these lines, they do not arise from the presence of any compound of carbon with nitrogen, while at the same time they do appear to belong to the element carbon.

Of the three lines given above, that with the wave-length 3589·9 appears when sparks are passed between dry electrodes of graphite

Variations in the carbon spectrum as observed in different circumstances.		Other spectra for comparison.	
Dry electrodes in air. (Hartley and Adeney.)	Dry electrodes in air. Ten lines absent. (Hartley.)	Dry electrodes in CO_2 . Seven lines absent, others lengthened and strengthened. (Hartley.)	Dry electrodes in oxygen. Three lines absent, others lengthened, marked thus.* (Hartley.)
λ			
4266·3	absent	4266·3	4266·3
3919·5	"	3919·5	3919·5
3881·9	"	3881·9	3881·9
3875·7	"	3875·7	3875·7
3870·7	"	3870·7	absent
3589·9	"	3589·9	3589·9
3584·8	"	"	absent
3583·5	"	3167·7	3167·7
3167·7		3167·7	3167·7
3166·0		3166·0	3166·0
2993·1		2993·1	2993·1
2967·3		2967·3	2967·3
2836·7		2836·7	2836·7
2835·9		2835·9	2835·9
2746·6		absent	*2746·6
2640·0			*2640·0
2511·6		2511·6	2511·6
2508·7		2508·7	2508·7
2478·3		2478·3	2478·3
2297·7		2297·7	*2297·7

Carbon lines. (Eder and Valenta, "Über das Emission-spectrum des Elementaren Kohlenstoffes." Kaiserl. Akad. Wissens. Vienna, 1893.)

4267·5
3920·8

Edges of cyanogen bands. (Käyser and Runge, "Über die Spektren der Elemente," Königl. Preuss. Akad. Berlin, 1889.)

This is by far the strongest of the cyanogen bands
3883·6 edge
3871·5 edge
3590·5 edge
3585·9

4267·5
3920·8

in an atmosphere of oxygen; this can scarcely be considered a cyanogen line. There remain now the two 3584·8 and 3513·5, and, as these lines are absent from the spectra taken in oxygen and in carbon dioxide, it may well be questioned whether their origin is elementary carbon.

From their occurrence in the spectra taken in air and their being lengthened when moistened electrodes are used, it seems that for their production nitrogen is necessary and water vapour advantageous; but they are not yielded by cyanides, and, therefore, in the absence of any good reason for this, they cannot be attributed to cyanogen. A further examination of the list of lines will show that there are seven attributed to carbon by Eder and Valenta and three assigned by them to cyanogen which do not always appear when powerful sparks are passed between graphite electrodes through air. Then we have four lines of carbon and three attributed to cyanogen which do not appear when the spark is passed through carbon dioxide. Liveing and Dewar ('Roy. Soc. Proc.', vol. 34, p. 428) have shown that mixed vapours do not give precisely the same spectra as the substances present in the mixture would give by themselves. In certain cases one element renders the lines of another more brilliant, while in other instances some of the lines disappear. Chlorides usually have the effect of sweeping out the fainter lines.

The lines at 3590·5 and 3585·9 and 3584 are closely adjacent to certain nitrogen lines which are somewhat strengthened in the carbon spectrum. As the carbon spectrum varies remarkably under different conditions, it may exercise an influence on the nitrogen spectrum, and at the same time be modified by the presence of an atmosphere of this gas. In order to test the probability of the carbon and nitrogen spectra being subject to variations when the two elements are together in the spark or flame, it is necessary to consider the effect of one spectrum on another when the two are produced simultaneously from quite different materials.

In the oxyhydrogen flame the water-vapour lines are prominent, but only two groups are visible in the spectrum under normal conditions, and with an exposure of half an hour. If, however, some sulphur be burnt in the flame, the conditions being otherwise unchanged, then the spectrum, in addition to a band of continuous rays and flatings characteristic of sulphur vapour, shows the water-vapour lines wonderfully strong, with groups extending beyond those portions of the spectrum usually photographed, and not only are the lines distinct, but dense, as if their radiating power or the chemical action of their radiations was greatly increased. This does not arise from the continuous spectrum merely overlapping and apparently strengthening the water-vapour lines, since new groups of

lines came into view which were too feeble to be visible on the other photographs. Sulphur is not the only substance which affects this spectrum, for instance, the banded spectrum of magnesia and the spectrum of lime also appear to intensify it.

It is probable that something similar takes place with regard to carbon; we know that the spectrum is modified by the surrounding nitrogen of the atmosphere, and the rays of carbon increase the intensity of the nitrogen rays adjacent to the carbon lines, the effect being increased in the case of the spark by a saturated solution of zinc or calcium chloride.

The facts here set forth certainly favour the view that the lines in Hartley and Adeney's spectrum of carbon are the lines of the element and not merely the edges of cyanogen bands. Finally, I would point out that the carbon spectra of Eder and Valenta are not quite the same as those obtained by me, for if the photographs published in the 'Journal of the Chemical Society,' vol. 41, p. 91, are carefully examined with a strong magnifier, it will be seen that the graphite spectrum, No. 10, on Plate II, yields neither the group III nor group IV of cyanogen as depicted in spectrum No. 4 of the photogravure plate illustrating Eder and Valenta's paper; at the same time it may also be remarked that it does not resemble the spectrum of moistened electrodes to which I have already drawn attention.

III. "Electrical Interference Phenomena somewhat analogous to Newton's Rings, but exhibited by Waves along Wires." By EDWIN H. BARTON, B.Sc., late "1851 Exhibition" Science Scholar. Communicated by Professor ARTHUR W. RÜCKER, M.A., F.R.S. Received February 20, 1894.

(Abstract.)

1. The preliminary paper* on this subject gave the results of a single experiment, and approximately accounted for them by a mathematical theory of the phenomena involved.

2. The present paper discusses the question of disturbances, and gives nine experiments. Two of these are similar to the first experiment, but were made under better conditions; the others were made either to lead to these improved conditions or in confirmation of the original fundamental conclusions.

3. The disturbances alluded to arise from the fact that the electrical waves are not suddenly lost after their first incidence upon the abnormal part of the secondary, but course to and fro until they die out. A method of avoiding the greatest disturbance due to this cause is

* 'Roy. Soc. Proc.,' vol. 54, pp. 85—96, 1893.